ESME Workbench Innovations

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LONG-TERM GOALS

The goal of this project is to create a totally new version of the ESME (Effects of Sound in the Marine Environment) Workbench. The ESME Workbench is software simulation system that will serve as an educational and a basic research tool for the marine mammal research community and, in the longer term, will serve has as an aid for environmental planners who need to assess the potential impact of Naval training exercises on marine animals.

OBJECTIVES

1. Finalize ESME software architecture and develop capability for simulating and analyzing 3D sound fields produced by fixed sources

2. Add capacity to simulate moving sound sources and to do acoustic footprint analysis

3. Integrate moving sound source with animal behavior model provided by Biomimetica, Inc. and provide analysis tools for dynamic simulation output.

4. Implement simulation of moving mammalian sound sources with fixed and moving receivers and provide tools for animal detection analysis

5. Add capacity for simulating single explosive sources, create and test prototype ESME data portal

6. Add capacity for simulating multiple explosive sources integrated with animal behavior model and complete fully featured ESME data portal

APPROACH

The ESME Workbench simulation system is a product of the Office of Naval Research's research program on the Effects of Sound in the Marine Environment (Gisiner et al., 2006). Many groups contributed software and were integrated into a MATLAB prototype (Shyu and Hillson, 2006). The Boston University Hearing Research Center in collaboration with Heat, Light, and Sound Research, Inc. and Biomimetica, Inc. are now in the process of building on this previous work to create a production quality simulator for marine mammal research.

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The simulator user interface uses the GIS approach of treating different data types as layers in a geo-referenced coordinate system. The display of individual layers can be turned on and off and one layer is selected as the active layer. Depending on which layer is chosen as the active layer, additional information can be displayed, or analyses can be performed.

WORK COMPLETED

The basic ESME software architecture has been finalized and our first release of the software provides the capability to simulate and to visualize 3D sound fields produced by fixed sources. 3D sound fields are calculated by computing a series of 2D radial transects originating at the source and then interpolating the results within the cylindrical volume defined by the transects. The source and transect locations are superimposed on the bathymetry in the user console window (Figure 1). We also provide the capability to collapse the 3D field into a horizontal 2D field (footprint) by taking the maximum, minimum, or mean value in the water column for each horizontal location. The current release allows the user to import environmental parameter datasets downloaded from NAVOCEANO's GDEM-V and DBDB-V and NOAA's NGDC databases. The user can user select sediment types from a generic list and can specify and save sound source parameters.

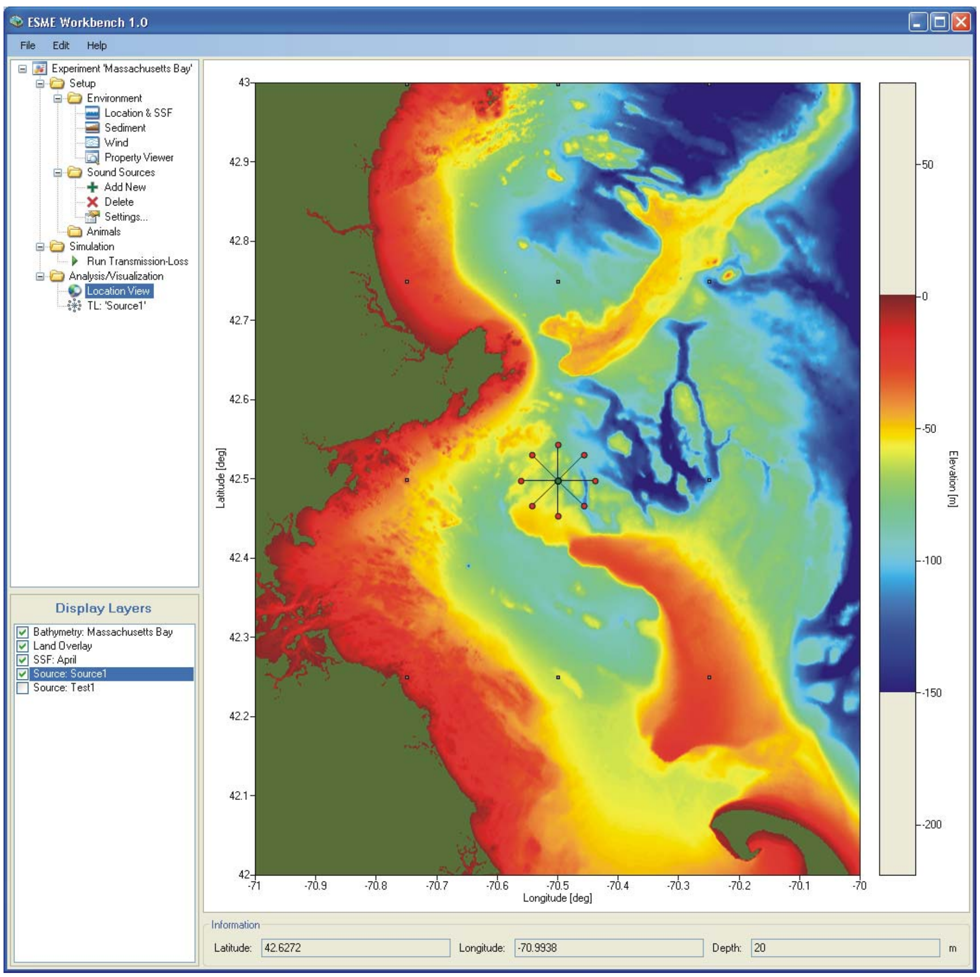

Figure 1. A typical display on the ESME user console showing Massachusetts Bay, Jefferies Ledge, and Stellwagen Bank.

We have also provided the capability to save and later reload all parameters related to a specific simulation. Tools are provided for report generation including the ability to export charts and graphs in a variety of standard graphics file formats (Figure 2) and to export transmission loss and sound field data as CSV text files.

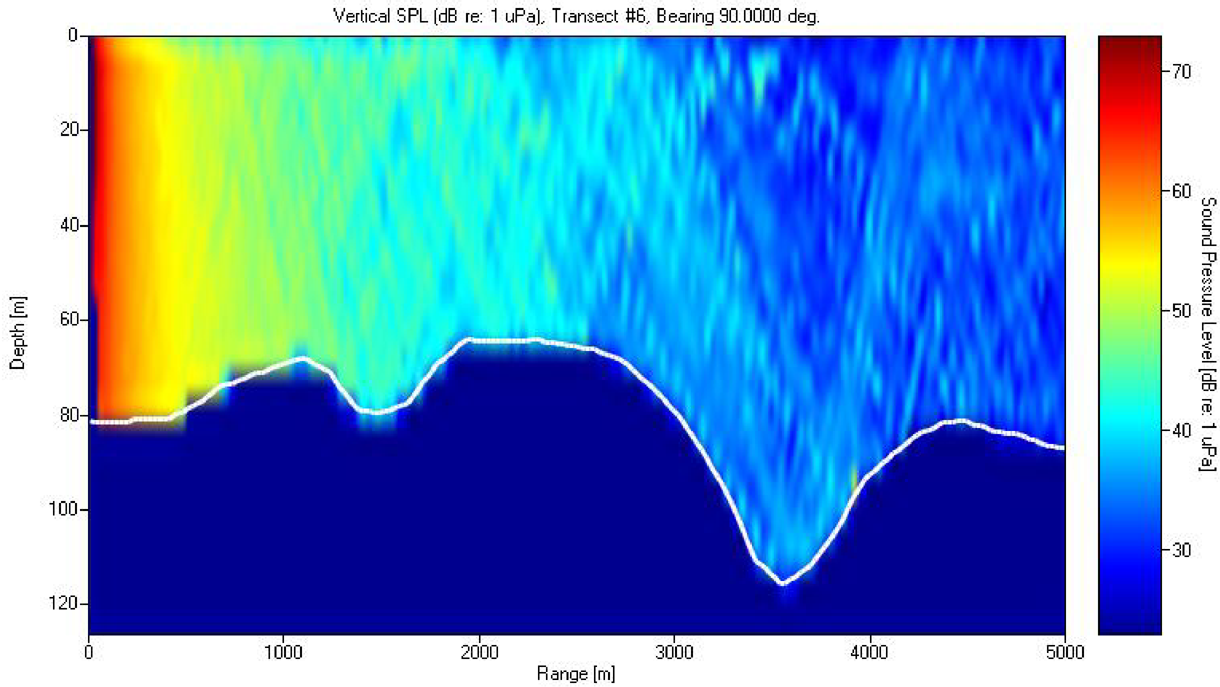

Figure 2. Vertical sound field plot produced by the ESME graphical export function

Transmission loss (TL) calculations are done using the BELLHOP ray tracing algorithm (Porter and Liu, 1994). This algorithm, which is coded in FORTRAN, combines good accuracy with fast computation times (especially when compiled with the INTEL compiler). We use a multiple thread approach for the TL calculations which allows us to make good use of the newer mulitcore processors.

The current release can import and display ship-track files that specify ship latitude and longitude as a function of time as well as sonar beam direction and beam width. Future releases will include additional parameters such as ping duration and duty cycle. Work is well underway for the next major release of the software. The major enhancement in the new release will be the ability to simulate animals reacting dynamically to fixed sound sources. We have integrated the animal behavior model provided by Biomimetica, Inc. into the workbench and have successfully simulated single animals reacting to single and multiple fixed sound sources. The animal position is over-plotted on the bathymetery so that the user can watch the progress of the simulation. Data logs that include the time history of animal position, behavioral state, and sound exposure level are stored as text files. Work remains to be done, however, on the user interface before the new version of the workbench will be ready for beta testing.

Because it is difficult to visualize the relationship between the simulated animals and the sound source and bathymetry, we have developed a 3D visualization system (Figure 3) using approaches pioneered by the computer game industry. Ships and animals are rendered using readily identified icons and the sonar beam pattern is rendered as a transparent fan on the surface and as a spotlight illuminating the seafloor beneath the surface. Users can quickly pan, zoom, and fly over the animation of the simulation using simple mouse and keyboard commands (Figure 4).

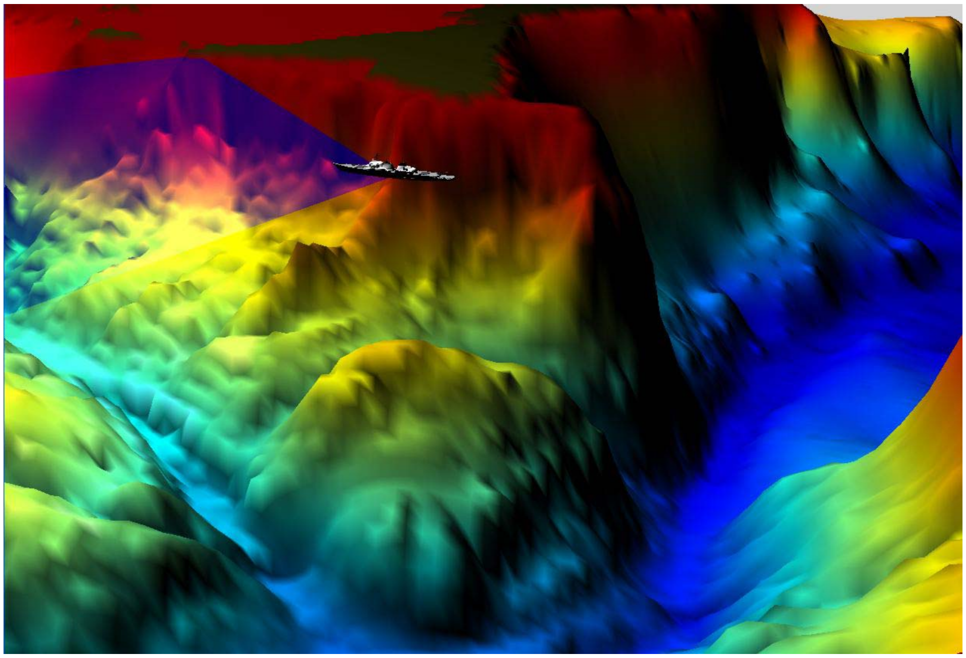

Figure 3. 3D visualization of bathymetry, ship and sonar beam

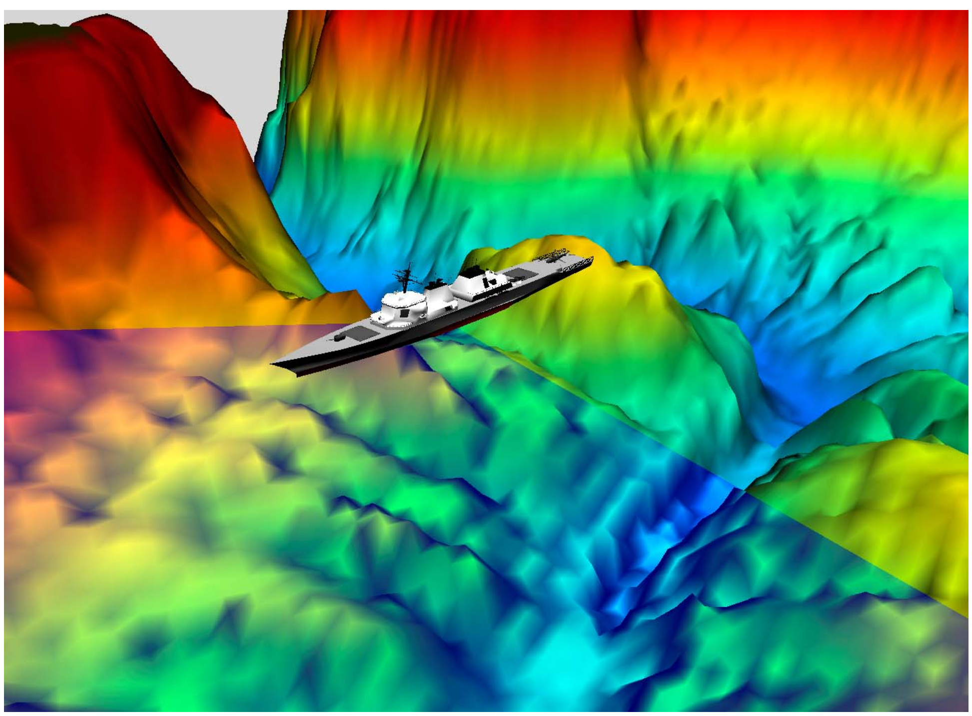

Figure 4. Zoomed in 3D view of ship and sonar beam

RESULTS

We have made significant advances in developing user interface and data visualization tools for complex acoustic simulation problems. Our test users have found the use of a graphical menu tree and the GIS graphical approach for visualizing simulation parameters very helpful. The 3D visualization of the simulated animal movements and their relationship to the location of the sound sources have turned the difficult task of interpreting 2D projections of 3D data in to an easy and intuitive task.

IMPACT/APPLICATIONS

The combination of acoustic simulations with animal behavior simulations will allow scientists and environmental planners to develop a deeper understanding of the problems associated with the impacts of anthropogenic sound sources on marine animals. In addition, the user interface tools that we are developing could be adapted for use in other complex simulation problems.

TRANSITIONS

None

RELATED PROJECTS

The project is part of a collaborative effort that includes award N0001407C0793 to Dorian Houser, Biomimetica, Inc. and award N0001407C0392 to Martin Siderius, Heat Light and Sound Research, Inc. Dorian Houser's group is supply the animal behavior modules for the workbench and Martin Siderius's group is assisting us with the acoustic propagation models.

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NGDC http://www.ngdc.noaa.gov/

PUBLICATIONS

Mountain, D.C., Anderson, D., Vajda, V. and Siderius, M. Using Simulation to Design Passive Acoustic Monitoring Systems. Abstracts: 3rd International Workshop on Detection and Classification of Marine Mammals using Passive Acoustics. Boston July 24-26, 2007.

PATENTS

None

HONORS/AWARDS/PRIZES

None